INDIA'S NATIONAL LABORATORIES

THE PUBLICATIONS DIVISION
Ministry of Information and Broadcasting
Government of India

April 1954

Re. 1/8   2s. 6d.   35 cents

CHAPTER I

INTRODUCTION

PRIOR to World War II, organized scientific and industrial research under Government auspices received very little attention. A number of universities and institutes were engaged in research, mostly on fundamental aspects of science. A few industries also had their own research organizations. By and large, however, industry depended on foreign techniques and had no research programmes of its own.

The war forced the pace of scientific advancement. As the main supply base for the Allied Forces in the Middle and the Far East, India was far too important to be ignored. The Government of India, therefore, sought the aid of science to make the most of the available resources.

Meanwhile, India had become research conscious and her contribution to fundamental research as well as the fact that a number of Indian scientists had won international fame forced the Government to recognize the importance of science for national welfare. The Board of Scientific and Industrial Research was accordingly set up in 1940 and the Council of Scientific and Industrial Research in April 1942.

With the advent of independence, a greater emphasis came to be laid on the provision of additional facilities for the promotion of scientific and industrial research. The Prime Minister, Jawaharlal Nehru, recognized the paramount importance of science for national regeneration. Thus, on August 15, 1947, a separate portfolio was created for scientific research under his direct charge. This was

followed by the creation of the Department of Scientific Research on June 1, 1948. In 1951, the Department was expanded and renamed the Ministry of Natural Resources and Scientific Research.

Among the diverse nation-building activities undertaken by the present Government, the most significant is, perhaps, the opening of a chain of national laboratories in different parts of the country. It was realized that the standard of living for a vast population could be raised only through planned effort. This could, in turn, be achieved by pressing science into the service of the manufacturing industries.

Speaking at the opening ceremony of the National Chemical Laboratory at Poona on January 3, 1950, the late Professor James W. McBain, F.R.S., said: "India is using her newly-won freedom to turn to science for the amelioration of the conditions of the life of her people and to participate in the progress of Western civilization."

Eleven national laboratories have, meanwhile, come into being. Six of them, namely, the National Chemical Laboratory at Poona, the National Physical Laboratory at New Delhi, the Fuel Research Institute at Dhanbad, the Central Glass and Ceramic Research Institute at Calcutta, the Central Food Technological Institute at Mysore and the National Metallurgical Laboratory at Jamshedpur were opened before the end of 1950. Then followed the Central Drug Research Institute at Lucknow in January 1951 and the Central Road Research Institute at New Delhi in June 1952, the Central Electro-chemical Research Institute at Karaikudi and the Central Leather Research Institute at Madras, both in January 1953 and the Central Building Research Institute at Roorkee in April 1953.

The National Physical Laboratory and the National Chemical Laboratory are concerned with fundamental research in general and the development of the industry as a whole, while the remaining nine laboratories are specialized institutions dealing with the problems of specific industries. The main function of all these institutes is to seek new knowledge in fundamental and applied research.

They will examine the existing industrial processes and suggest improved techniques of manufacture and produce standard materials cheaply. Furthermore, they will evolve new processes and products and assist new industries to be started.

The building of the eleven laboratories has now been completed. Among the other projects included in the plan are the Central Salt Research Institute at Bhavnagar, a Radio and Electronics Research Institute at Pilani and a Mechanical Engineering Institute at Calcutta. The foundation-stone of the Electronics Institute was laid by the Prime Minister on September 21, 1953. The Central Salt Research Institute is expected to start functioning shortly in Raj Hotel building at Bhavnagar. This leaves only one institute to be completed during the period of the first Five Year Plan.

An important feature of the opening ceremonies at most of the laboratories has been the presence of the Prime Minister. It is symbolic of his profound personal interest in science and its application for the good of the people. To quote his own words, he has found it an "exciting conception to see large number of young men and women coming into these laboratories and research institutes in India and working with zeal and enthusiasm for the advancement of science in India and, through science, the advancement of the Indian people."

The programme of establishing the laboratories, however, owes its speedy implementation to the foresight, initiative and drive of Dr S. S. Bhatnagar. "We consider," observed Doctor Irene Joliot Curie, Director, Curie Laboratory, Paris, "that at no time in the history of the scientific evolution of any country, one single person has done such an enormous service to science and has achieved such a great success in such a short period as Sir Shanti Bhatnagar. He is full of fruitful ideas and is bestowed with vigour and energy to execute them."

The Central Government have provided Rs. 53,805,000 for the construction and equipment of the laboratories. The

public and the State Governments, too, have shown a keen interest in them and several munificent donations have been received in the form of funds and sites for buildings.

The national laboratories conform to the highest standards and rank among the finest institutes of their type in the world. They have been planned by expert committees consisting of scientists and industrialists and they incorporate many of the best features of advanced laboratory designs in foreign countries and are equipped with the latest instruments which were not available in India so far. Also, they are located near the main industries which they are intended to serve. A novel feature of the laboratories is the provision for pilot plants where the results of research can be tested for their commercial value. Moreover, leading Indian scientists have been invited to direct their activities and, where necessary, eminent foreign scientists have been engaged to guide research.

Thus, not only has the foundation for organized scientific and industrial research been laid, but science has been assigned its proper place in the task of national reconstruction. Indeed, for the first time, India's young men and women will have opportunities and facilities for the pursuit of science and its application to national welfare.

CHAPTER II

NATIONAL CHEMICAL LABORATORY

THE chemical industry in India is in its initial stages of development and not yet sufficiently alive to the value of research. In September 1941, it was, therefore, decided to set up an institute for chemical research. The work of construction began at Poona in February 1948 and the opening ceremony was performed by the Prime Minister on January 3, 1950, before a distinguished gathering which included some of the world's most eminent scientists. The National Chemical Laboratory was the first of the eleven national laboratories to be established in India.

Speaking at the inauguration, Sir Robert Robinson, the President of the Royal Society, London, said : "This enterprise is an expression of the vitality of India, and it will be one of the factors that will lead to an acceleration of scientific and industrial development in this half continent of such immeasurable potentialities."

The late Professor James W. McBain, F.R.S., was appointed the first Director of the Laboratory. Professor G. I. Finch, F.R.S., took charge as Director in September 1952.

BUILDING AND EQUIPMENT

The Laboratory is situated on an open plateau about five miles from the city of Poona. The main building is a magnificent structure, 640 feet long and 205 feet wide. It has a basement and four floors for the laboratories of the

seven divisions, the library, the auditorium, the museum, workshops, cafeteria, stores and offices. A remarkable feature of the Laboratory is its supply of water, gas, electricity and steam.

The library is housed in a spacious hall and contains over 25,000 volumes of books and periodicals on pure and applied chemistry. Microfilms on various subjects and a Kodak microfilm reader are available in the library.

The auditorium is equipped with modern film projectors and "public address" system. The museum displays samples of products made at the Laboratory, of chemicals and apparatuses from manufacturers in India and of different industrial plants.

SCOPE AND FUNCTIONS

The aim of the Laboratory is to show how chemistry can help in the development of the country's natural resources. Its scope and functions are thus wide and embrace the chief applications of chemistry.

Among the subjects, the following are included: (i) the survey of raw materials and their industrial potentialities; (ii) the development of key industries; (iii) the utilization of by-products of existing industries; (iv) fundamental research and application of results to problems of industry; (v) aid to industries; and (vi) the provision of training in specialized fields of chemistry and technology.

The Laboratory serves as a link between the universities, the Government and the scientific institutions on the one hand and the industry on the other. About 25 per cent of its efforts is devoted to the execution of fundamental research likely to help overall industrial advancement. The remaining 75 per cent goes to applied and development work for the improvement of the existing processes, better utilization of raw materials and the discovery of new processes and products. Such work, where necessary, is carried up to the pilot plant. Investigations of a major nature requiring large funds and materials are the chief concern of the Laboratory.

To carry out these functions, the Laboratory is divided into seven divisions, one each for biochemistry, chemical engineering, inorganic chemistry, organic chemistry, physical chemistry, plastics and polymers as well as survey and information.

RESEARCH AND DEVELOPMENT

New Processes and Products—Carbohydrate materials have been made the basis of a number of investigations at the Laboratory. Starch, for example, is both an industrial chemical and a raw material for many fermentation industries. The shortage of cereals in the country, however, has hit the starch industry severely and her starch requirements have been met either by imports or by manufacture from the imported grain. A new process has now been developed by which an enzyme produced by micro-organisms can be used for the liberation of starch from tubers. The details of the production of glucose from starch, too, have been studied.

Meanwhile, fermentation processes for the production of citric acid used in food, pharmaceutical and textile industries, a new enzymic process for the manufacture of calcium gluconate and the details for the production of vitamin C from starch have been worked out. A new process for the conversion of sugar alcohol sorbitol into sugar sorbose has also been developed.

Micro-organisms have been used for the production of a number of industrially valuable enzymes. These include enzymes for the clarification of fruit juices, for the desizing of textiles and for the curing of coffee. In addition, new proteolytic enzymes used in the preparation of protein hydrolysates and for other purposes have been prepared.

Experiments on the preparation of gelatin as plasma substitute in blood transfusion are nearing completion. By a new process developed in the Laboratory, it has been possible to produce a gelatin combining low viscosity with high molecular weight.

Cheap sources of proteins have been utilized for the production of valuable amino acids. Thus, glutamic acid used in the food industry has been produced from oil-cakes. Using fatty acids obtained from hydnocarpus and shark liver oils, new bactericidal compounds, equal to best foreign preparations, have been synthesized.

Pilot Plant Investigations—Processes have been developed for the economic utilization of India's waste and surplus materials. These include the pilot plant production of high-grade gelatin from bones and hides, the extraction of nicotine from tobacco waste, the production of chlorinated rubber waste and several industrial chlorinations.

A pilot plant with a rated capacity of 75 lb. of gelatin per day has been successfully operated. This gelatin possesses physical properties similar to those of imported one. Bone gelatin has been sensitized and found suitable for the preparation of photographic emulsions. The process for the manufacture of hide gelatin developed at the Laboratory has been leased out for commercial exploitation.

Chlorinated rubber finds use in corrosion-resistant varnish, paints and electrical appliances and insulating materials. The chlorination of crepe rubber has been expanded into a pilot plant investigation. The chlorinated rubber thus produced has been found to conform to specifications laid down for defence purposes.

Simple and economical processes have been evolved for the extraction of saponins from Indian soap-nuts and shikakai. The process has been patented in India and entrusted to the Madras Government for commercial development.

It is estimated that 4 to 5 million pounds of tobacco waste are available every year in India. A process has been developed on a pilot plant scale for its utilization in the preparation of nicotine sulphate solution. Nicotine sulphate has been found valuable for the control of pests. The process is patented in India, Turkey and America and is open to commercial exploitation.

Inorganic Chemistry—Cheap raw materials, other than

gypsum, have been used for the fixation of ammonia. Investigations have been carried out on the use of raw bitterns, a waste material from the sea salt works. Simultaneous ammonation and carbonation of the bitterns have given a crystalline soluble fertilizer containing 21 per cent nitrogen and 3 per cent potash. Field trial experiments are being made to test its efficacy as fertilizer. Pure magnesium carbonate, which is also obtained from this reaction, yields a pure white and light magnesia comparable to the imported one used as thermal and electrical lagging material. This process has recently been used for the preparation of pure ammonium sulphate, using epsom salt as raw material.

The only phosphatic fertilizer manufactured in India today is the superphosphate. Two new phosphatic fertilizers, namely, dicalcium phosphate and *kotka* type of semi-acidulated phosphate, have been produced on a pilot plant scale. A number of other processes have also been developed and by working them on a commercial scale considerable saving in the consumption of sulphuric acid can be effected.

Titanium tetrachloride is not manufactured in India at present. It is a well-known chemical used for defence requirements, in the manufacture of metallic titanium, titanium dioxide (pigment) and other titanium compounds. Optimum conditions have been established for its preparation on a pilot plant scale by chlorination of ilmenite and rutile, both found in the country. Titanium dioxide of a high pigment quality has been obtained from titanium tetrachloride, thus dispensing with the use of sulphuric acid.

Sodium tripolyphosphate is an important detergent material used in water softening, washing compositions and soap manufacture. It is not manufactured in India at present. A process has now been worked out for its preparation in crystalline form identical with that of the imported product.

Fundamental studies on the extraction of germanium, a rare metal, from indigenous sources, such as flue dusts and Nepalese sphalerite ore, have been undertaken. Conditions

have also been established for the decomposition of unground monazite sand by chlorination. A recovery of rare earths to an extent of 99 per cent and of thorium of 84 per cent has been achieved.

Organic Chemistry—Work has been done on the utilization of non-edible oils for industrial purposes, while methods have been worked out for refining oils, such as *neem, karanja, nageshwar* and cotton seed oil. By utilizing these oils industrially, it would be possible to save large quantities of edible oils now consumed in soap and other industries. Some work has been done on the utilization of non-edible drying oils like *kamala* oil and tobacco seed oil for use in the paint and varnish industry. Varnishes prepared from *kamala* oil are comparable to those of *tung* oil and are likely to find extensive use for decorative wrinkle finishes.

Optimum conditions have been developed for the preparation of 12-hydroxy stearic acid for multi-purpose greases in the lubrication of jet planes, for the elimination of saponin from *mahua* oil-cake for use as fertilizer and cattle feed and for the extraction of castor oil from castor seeds. In addition, work has been done on the refining and chemical modification of crude sugar-cane wax as a substitute for carnauba wax largely consumed in various industries.

Meanwhile, a number of essential oils have been examined. Synthetic aromatics have been prepared under standardized conditions. A new terpene has been isolated from the Indian spearmint oil and its structure has been established. Besides, the constitution of kamlolenic acid isolated from the *kamala* oil has been determined. The preparation of and research on weedicides has been started. Various rare chemicals have also been prepared for other research institutions.

Moreover, studies have been undertaken on items, such as the structure of the U.V. spectra of some naturally occurring xanthones, the oxidation of nicotine sulphate to nicotinic acid, the production of benzaldehyde and benzoic acid from toluene for use in the pharmaceutical and perfu-

mery industry and the isolation and chemical examination of various plant products.

Physical Chemistry—Research is in progress at the Institute for the determination of the structure of crystalline matter relating to proteins, soaps, etc., and on the various surface structure problems, such as electro-deposition, electro-polishing and lubrication. Processes are also being developed for growing synthetic gem crystals of ruby, sapphire and rutile used in jewellery and as bearings in the watch industry.

The infra-red spectrograph is being used for identification of organic compounds. The light scattering and ultra-centrifuge techniques are being used for determining the size, shape and molecular weight of macro-molecules, such as high polymers and proteins. Another simple technique, using thermister as the measuring device, is being applied for the determination of molecular weights, and satisfactory results have already been obtained for substances of low molecular weight in solutions.

A simple and inexpensive method of making stable suspensions of technical DDT in water is being developed. This should save much of the cost involved in the hitherto practised methods of using organic solvents like kerosene.

Photographic films and papers are consumed in fairly large quantities and they are all imported. Processes have been completed for the preparation and large-scale exploitation of negative and positive emulsions, using gelatin made in the Laboratory from hides and bones.

Plastics and Polymers—Researches carried out in the chemistry and physical properties of plastics and polymers include the development of synthetic surface coatings, wrinkle finishes, ion-exchange resins, battery containers, laminates, adhesives and chlorination of rubber.

Investigations have been undertaken to prepare ion-exchange resins from indigenous materials like coal, cashew-nut shell liquid, *bhilawan* nut shell liquid and napthalene. These resins should find extensive use in various fields, such as the softening and deionization of water, increased

recovery of sugar from cane juice and molasses and the recovery of certain metallurgical wastes.

Factice is largely used as a processing agent by the rubber industry in the manufacture of hospital sheeting and pencil erasers. It is imported at present, but research has shown that white and brown factice could be prepared from tobacco seed oil.

Compositions based on the natural rubber latex for sealing the seams of cans used for storing oils and other food products have been formulated. A process for the preparation of pressure sensitive adhesive tape, using cellophane paper as the base, has also been prepared. A chemical method has been found for degumming of ramie which is used extensively in the textile and rope industry.

Finally, baking enamels have been prepared from tobacco seed oil. These enamels can be prepared as plain and wrinkle finishes and should be in large demand in the country. Experiments have been made to fortify these finishes and a process has been patented in this connection.

SURVEY AND INFORMATION

The Laboratory is maintaining close liaison between its various divisions and the industry. Consultative and advisory work is carried out for industries and Government departments. Scientific and technical information is collected from patent literature and scientific publications or from experts and it is supplied to industries and research organizations.

Information is given to small-scale industries as well. Monographs are prepared on industrial subjects and experiments undertaken to solve *ad hoc* industrial problems.

GENERAL

An experimental farm is attached to the Laboratory and a beginning has been made with the cultivation of plants of economic importance, such as the essential oil-yielding

plants like *Mentha viridis, Polianthes tuberosa, Jasminum grandiflorum* and *Pelargonium spp.*

SYMPOSIA

Symposia covering fifteen major aspects of applied chemistry have been held in the Laboratory. These have brought together many hundreds of industrialists, scientists and technologists as well as the Central and State Government officials. The Laboratory has thus been able to learn, at first hand, many urgent practical problems of the various industries.

CO-OPERATION WITH OTHER RESEARCH INSTITUTIONS

Chemicals produced at the Laboratory have been supplied to the universities, while university laboratories are being helped to prepare chemicals required for research. A dozen co-operative projects have been undertaken in collaboration with institutions, such as the Indian Institute of Science, Bangalore, the Armed Forces Medical College, Poona, the Indian Institute of Sugar Technology, Kanpur, the Central Laboratories of Hyderabad (Deccan), the Forest Research Institute, Dehra Dun and the Malaria Institute of India, Delhi. The Indian Central Oil-seeds Committee, the Indian Council of Medical Research and the Indian Council of Agricultural Research are financing specific research projects in the Laboratory. Also, training in micro-analysis and glass-blowing is being given to individuals sent by research institutions and laboratories.

The Laboratory is expected to become the headquarters for research, development and testing for the proposed rubber research association of the Indian rubber industry. Similarly, the paint, varnish, lacquer and pigment industry has sought its assistance for research, development and testing instead of establishing a separate research institute of its own.

CHAPTER III

NATIONAL PHYSICAL LABORATORY

EARLY in 1943, the Council of Scientific and Industrial Research set up a committee to draw up plans for the setting up of the National Physical Laboratory. The foundation-stone of the latter was laid by the Prime Minister, Jawaharlal Nehru, on January 4, 1947, in the presence of a distinguished gathering of Indian and foreign scientists, including Sir Charles Darwin and Sir Harold Spencer Jones. Three years later, on January 21, 1950, the late Sardar Vallabhbhai Patel, then Deputy Prime Minister, declared the Laboratory open.

At the opening ceremony, Dr E. U. Condon, Director, National Bureau of Standards, Washington, U.S.A., said: "The rate at which you are building new research laboratories and the intensity of devotion to science that is to be found in your universities make it certain that in a few years India will be among the top-ranking countries of the world in scientific achievement and its practical application to human welfare."

The Laboratory is headed by the eminent scientist, Dr K. S. Krishnan, F.R.S.

BUILDING

The estate, on which the Laboratory stands, covers 70 acres of land. The building is an imposing modern structure. The front block forms the base of the letter L. The east wing has three floors and the west wing two, while

a basement runs along the entire length of the block. The main features of the Laboratory are: the provision of air-conditioning, flexibility of working space and a long basement serving as a store and tunnel for protected services like gas, steam, electricity and compressed air.

The library of the Laboratory is of modern design. Its imposing tower is 105 feet high. It has also a fan-shaped auditorium, a well-equipped workshop, a swimming pool and a club-*cum*-guest house.

SCOPE AND FUNCTIONS

Among the Laboratory's functions are: (i) the maintenance of and research on fundamental and derived standards; (ii) research on industrial standards, including standards of quality, performance and practice; (iii) investigations on raw materials for industries; (iv) the standardization of raw materials, processes and finished goods; (v) practical application of the results of fundamental research; (vi) the framing of and advice on specifications; and (vii) scientific and industrial testing.

Work here is done in the following nine divisions: (i) weights and measures; (ii) applied mechanics; (iii) heat and power; (iv) optics; (v) electricity; (vi) electronics; (vii) sound; (viii) industrial physics; and (ix) analytical chemistry.

ACHIEVEMENTS

Weights and Measures—Testing on weights and balances of local manufacture has been done at the Laboratory. A large number of instruments required for standardization work have also been designed and built.

Hypodermic syringes have been tested for performance and accuracy. A quartz clock has been assembled in which a 1,000 kc. quartz crystal is made to vibrate in a series of resonant circuit. Microwave transmitter/receiver units

operating in the 10 cm. and 3 cm. regions have been set up. A frequency meter for measuring frequencies of the order of 100 to 10,000 mc./s. has also been designed.

Finally, an electronic device, called the metal detector, has been constructed for the customs department for the prevention of smuggling of precious metals.

Applied Mechanics—A number of problems, such as friction in fluids, vibrations in machines, bridges and structures, welding and fabrication and the behaviour of materials under high pressure and vacuum have been studied. A portable vibration generator has been designed for the study of vibration engineering. Processes have been developed for the anodizing and colouring of aluminium and its alloys and for the chromium plating of aluminium to give it a hard and wear-resistant surface. An apparatus for measuring the thickness of electroplated coating has been designed. Accelerated weathering tests on foam concrete panels were also carried out for the Government Housing Factory.

Heat and Power—The possibility of utilizing solar energy for heating, air-conditioning and refrigeration and for the generation of mechanical or electrical energy has been explored, including cooking with solar heat. The equipment for the latter consists of a reflector by which heat is concentrated on an insulated, pressure type cooking vessel. Mounted on a frame, the reflector can be rotated to receive radiation from the sun.

A testing laboratory for oil engines and power machinery of medium and small sizes has been set up at the Laboratory to test and certify portable producer gas plants for transport vehicles. Research on alternative motor fuels, such as producer gas, rectified spirit, power alcohol and power alcohol-petrol blends, has also been undertaken. The use of vegetable oils and colloidal fuels as diesel fuels has been tried.

Optics—Photographic standardization, research on photographic materials, the development of lenses, cameras and microscopes and the maintenance of absolute standards for

illumination are other major activities of the Laboratory. A photo multiplier unit for the measurement of light intensities has accordingly been designed and built. An analysis of several types of materials used in the processing and producing industries was conducted and assistance given to the Geological Survey of India, the Rare Minerals Survey, the Atomic Energy Commission and other organizations. The purity of rare earths produced in the processing of monazite sands is being tested in the newly created x-ray unit.

Special mention may be made of the metal evaporation unit built at the Laboratory for coating surfaces with thin metallic films. Aluminized surfaces have thus been prepared for various types of interferometers. A new method has also been evolved for determining accurately the principal refractive indices of crystals.

Electricity—The scientific instruments industry has been assisted in testing and calibrating Wheatstone bridges, resistance boxes, post office boxes, meters and other electrical apparatus required for teaching and research, while a number of precision electrical instruments have been installed to test articles like household meters, fans, transformers and lamps.

Single and multi-stage metal oil diffusion pumps, a demountable type of x-ray tube, an x-ray spectrometer and different types of scalers have been constructed. Simple binary alloys exhibiting order-disorder phenomena have also been prepared.

Electronics—The electron microscope at the Laboratory has attracted research workers from all parts of the country. Important problems like the morphology of diatoms, diffraction patterns of minerals and liquid gold deposits on porcelain surfaces have been studied. Processes have also been developed for the manufacture of important components. The production of silver mica capacitors, high frequency ceramics, electrolytic capacitors, volume controls, glass for valves, etc., has been started on a pilot plant scale. The 'printed circuits' technique for the manufacture of electronic

equipment developed during World War II is being applied to the production of radio components from indigenous raw materials. A high temperature sintering furnace and auxiliary equipment have been built in the workshop for the study of high dielectric and high frequency ceramics. A new method for determining the thermionic constants of metals and semi-conductors has also been developed in the Laboratory. In addition, the optical emissivity of graphite at different high temperatures has been determined.

Sound—Fundamental research on ultrasonics has been in progress for the past few years. More recently, interesting results were obtained on the relation between sonic and thermal energies. Tests on acoustic properties of foam concrete panels were carried out for the Government Housing Factory. The manufacturers have also sought the help of the Laboratory for the testing of prototypes for loud-speakers assembled in India.

Industrial Physics—The importance of carbon products for many industries has led to investigations on the production of various types of carbon compositions. A pilot plant has been designed and built and it is capable of producing 500 brush blocks per week. The hazards to operators from inhaling carbon particles have been completely eliminated from the magnetic separator, which is an auxiliary to the plant.

By utilizing a 200-ton hydraulic locomotive tyre press, an extruding machine has been set up to manufacture carbon rods of larger diameter for the electro-chemical industry. Pilot plants have also been set up for the production of arc carbons for the cinema industry and carbon rods for the dry cell manufacture as well as for the purification of Indian graphite used in the manufacture of dry cells, carbon brushes, pencils and crucibles.

Lastly, a process for the preparation of activated manganese dioxide from indigenous raw materials has been worked out and a pilot plant set up to study its commercial possibilities.

Analytical Chemistry—Analysis and testing of alloys,

ores, plastics and structural materials have been done for the Ministry of Natural Resources and Scientific Research, the Atomic Energy Commission and other Government and semi-Government organizations and private industry. At present, equipment is being designed for the large-scale extraction of helium required for the Collins liquefier.

NATIONAL DOCUMENTATION CENTRE

The Indian National Scientific Documentation Centre has been established in collaboration with UNESCO. The latter has lent an adviser each in documentation and abstracting and in scientific translation as well as a technician in the photographic and photo-mechanical reproduction of documents. It has also agreed to award fellowships and study grants to the extent of $8,000. Equipment worth $24,000 and materials and scientific journals worth $12,000 will also be provided. The immediate programme of INSDOC is to build up a library of leading scientific periodicals and to supply photographic copies of articles.

CHAPTER IV

FUEL RESEARCH INSTITUTE

THE reports of the Coal Commissions of 1928, 1936 and 1946 drew attention to the need for scientific investigation of the coal resources of the country. Eventually, the various problems connected with coking coal and the limited supplies of liquid and gaseous fuel led to the setting up of a Fuel Research Committee. In August 1940, the Committee recommended the establishment of a Central Fuel Research Station.

The foundation-stone of the Institute was laid on November 17, 1946, and it was opened by the President, Dr Rajendra Prasad, on April 22, 1950. Speaking on the occasion, he said: "I am quite sure this Institute, with its local or satellite survey laboratories, when they are in full working order, will be able to help in the best utilization of our fuel resources and particularly of coal."

Dr J. W. Whitaker is the Director of the Institute.

BUILDING AND SERVICES

The Institute is approximately 70 miles from Jamshedpur and stands on 170 acres of land. The front building faces the main Jharia-Sindri Road with the administrative offices, assembly hall and the museum. The other parts have specialized research laboratories, the library and photographic studios, coal and coke testing and carbonization research laboratories, inorganic and micro-chemical laboratories and miscellaneous research sections. There is

also a technological block as well as a coal-dressing laboratory. The services comprise water supply, gas, electricity, compressed air and vacuum.

SCOPE AND FUNCTIONS

Research at the Institute deals with solid, liquid and gaseous fuels. The work covers broadly (i) the assessment of fuel resources; (ii) the use of the different types of fuel; (iii) improvement in fuel economy and the preparation and purification of solid fuel; (iv) fundamental studies of fuels; (v) spontaneous combustion and its prevention; (vi) carbonization of coal; (vii) gasification of solid fuels; (viii) hydrocarbon synthesis; and (ix) hydrogenation of coal and tar.

RESEARCH AND DEVELOPMENT

COAL SURVEY

The Institute is engaged primarily on the assessment of the country's coal resources. The basic work includes physical and chemical examination of the coal seams as well as of commercial grades of coal, including their washability. The results are correlated with actual usage in order to help the industry. Fuel economy and industrial efficiency are thereby effected by the coal survey organization.

Another purpose served by the survey is to find out the extent of the available supply of each type of coal during the next 25, 50 or 100 years to assist proper industrial planning and to regulate the supply and proper utilization of each type of coal.

Meanwhile, the following five regional coal survey stations have been established at Jealgora for the Jharia coal-fields, Raniganj for the Raniganj coal-fields, Ranchi for the Bokaro-Ramgarh-Karanpura coal-fields, Bilaspur for the Central Indian coal-fields and Jorhat for the Assam coal-fields.

Already, several hundred samples from the Jharia and

Raniganj coal-fields have been investigated, of which over 440 have been analysed for industry or for private parties, excluding those done for washability characteristics. The testing has shown that several types of coals were suitable for direct coking, mixing with low volatile coal in coking blends, gas production and tar recovery at gas works and low temperature carbonization. Mine air analysis for the control of ventilation and fires in mines has also been done.

In the Bokaro coal-fields, a survey of the Bermo seam was undertaken to assess its suitability for the thermal power plant of the Damodar Valley Corporation.

The coal deposits found in Madhya Pradesh and Vindhya Pradesh have been surveyed. The washability tests having been found favourable, the Associated Cement Company has decided to erect a coal-washing plant at Nowrazabad (Rewa). A process for the recovery of pyrites from the washery rejects, which can be used for the manufacture of sulphuric acid, has been worked out. The washability characteristics of the coal seams of Hyderabad have also been investigated, while preliminary work has been done on coals from Assam.

UTILIZATION

Railways—Ninety per cent of the coal required by the railways is for the consumption of the locomotives. To conserve its supply, the use of pre-heated secondary air has, therefore, been suggested for loco boilers using non-coking coals. At the same time, assistance is being given in designing a combustor, a coal feed arrangement, a combustion chamber, etc., for gas turbine locomotives fired by coal dust.

Low-grade Coals—Many of the coal seams in India are of inferior grade because of their high ash content. The cleaning of high ash coal has, therefore, been undertaken as a major item of research at the Institute. Other investigations include studies on the heavy medium process, jig

washers, the cyclone process, froth flotation, controlled breakage, etc.

Power Generation—The 200,000 kw. thermal power station at Bokaro will consume about 2,000 tons of coal per day. Technical assistance has been given in the testing and selection of coals for this plant.

Coal Utilization—A large percentage of the Indian coal is of the slack variety, i.e., of less than one inch thickness. Briquetting of such coal for domestic or commercial use offers an important outlet. Briquetting tests have accordingly been done on slacks from non-coking Raniganj coal.

Carbide Manufacture—The adoption of suitable size and washing technique led to the production of coke with 6 to 8 per cent of ash and 0.002 per cent of phosphorus. The production of low ash coke for the manufacture of electrodes is in progress.

Soft Coke for Domestic Use—Experiments with low temperature carbonization are being made and valuable tar and soft coke are expected to be obtained by this process. The latter can be utilized as smokeless domestic fuel. By developing low temperature carbonization industry on a sound basis, it will be possible to eliminate smoke nuisance in the big cities and in the coal-fields.

Spontaneous Ignition and Storage of Coals—Large quantities of coal are destroyed or sealed off by fires through the self-heating of coal in the mines and at depots and in ship's bunkers. The mechanism of self-heating has been studied and methods of storage are being evolved to reduce the risk of fire. Different types of coal have also been tested for self-heating.

Breakage of Coal—Coal has to be broken into pieces during mining and they are of different sizes. A survey has accordingly been undertaken by the Institute and research on 'breakability' has led to the determination of a new 'toughness factor.'

Lignite Investigations—Simultaneously, samples of lignite from South Arcot have been analysed and tested and its montan wax content studied for commercial extraction

and utilization. Lignite found here is not dissimilar to Australian and German brown coal. By successfully exploiting this source of supply, it may be possible to set up a large thermal generating plant fired by raw or partly dried lignite. Some of the lignite may also be briquetted and carbonized. This will quicken the industrialization of the south which will now have its own supply of solid fuel.

Carbonization

The shortage of metallurgical coke has been one of the handicaps of the iron and steel industry. Research has shown that if the results so far achieved are properly utilized, the life of India's coking coal reserves can be roughly doubled.

The possibility of using the Central Indian coal for the proposed iron and steel plant in Madhya Pradesh has been explored. It has been found that, mixed with high-grade Jharia or Bokaro coking coal, this can be used for the manufacture of metallurgical coke.

Coke oven operating conditions and their correlation with tar yields have been studied. Coke breeze (fines) from the Bhowra coke plant has been tested for use in the Simon Carves coke oven battery at the Hirapur Works of the Indian Iron and Steel Company. The oven operating conditions of the Government coke oven plant at Giridih have also been examined.

An electrically heated carbonization oven (charge 400 lb. coal) has been installed at the Institute. It is complete with by-product recovery train and the testing of the carbonization properties of coal is done along lines followed by the Bureau of Mines—American Gas Association.

Coal Products

Coal Tar Investigations—Experiments on tars have been conducted, particularly to discover the causes of their low yield and low acid content. The excessive cracking on the inorganic matter (aluminium silicate) is probably

chiefly responsible for them. The properties of tar produced in different ovens have been examined in this connection and correlated with the oven operating conditions.

Benzol Recovery—Excise duty has largely discouraged the recovery of benzol from by-product coke oven plants. At present, out of the installed capacity of over 1.8 million gallons, only about 0.8 million gallons of benzol are being recovered annually. At the suggestion of the Institute, the Government are reviewing the position. The full recovery of benzol from the existing coke oven plants will save at least Rs. 2½ million in foreign exchange from reduced imports of petroleum, while the recovery of benzene and toluene will meet our defence requirements.

Special Products from Coal—The following important products have been prepared from coal at the Institute: (i) active carbon from bituminous coal and lignites; (ii) zeo-karbs for water softening, for the manufacture of glucose from starch and for use as 'life savers' for the Defence personnel marooned at sea; (iii) ashless carbon for the manufacture of electrode carbon and other moulded products; (iv) indene and coumarone type of resins from Indian coal tars for paint, varnish, rubber and paper industry, floor coverings, printing inks and adhesives; (v) montan wax from South Arcot lignite; (vi) sulphur during carbonization; and (vii) pyrites from the washery rejects from coal. The cost of recovery is expected to be very low. Large quantities of some of these materials are, at present, imported.

Synthetic Oil

Fischer-Tropsch Synthesis—It is proposed to set up a synthetic oil plant and several coal seams and areas have been surveyed for this purpose. In the meantime, work has been undertaken on the Fischer-Tropsch synthesis and hydrogenation of coal and tar. Experiments on improved catalysts have led to the discovery of active catalysts. A pilot plant has been constructed on the 'fluidized' principle

and it is capable of producing about a gallon of oil per day. A high pressure coal and tar hydrogenation laboratory has also been set up and certain types of coal (200 mesh) have been successfully hydrogenated.

Gasification—About two-thirds of the cost of production of synthetic oil is accounted for by the production and purification of synthesis gas, i.e., carbon monoxide and hydrogen. Hence gasification of Indian coal and coke is economically important. This has been done by fluidization and a fluidized technique has been evolved for the rapid carbonization of pulverized non-coking coal at low temperature. This method gives high yield of primary tar for hydrogenation and also a reactive residue for gasification. A pilot plant for the gasification of 50 lb. of coal (200 mesh) per hour with steam and oxygen is under construction.

STANDARDIZATION

For purposes of standardization, the Institute works in collaboration with the Indian Standards Institution. It gives advice on standard specifications for sampling, size-grading, analysis and testing of coal and coke. Thus, in sampling and sizing, many new suggestions have been made. New methods of analysis and testing have been developed for the determination of nitrogen, phosphorus, volatile matter, calorific value, ash and moisture. Meanwhile, Indian and international standards have been framed for the analysis and testing of coal.

FUNDAMENTAL RESEARCH

Fundamental research has not, however, been neglected. Experiments have thus been carried out on coal-cleaning, analytical chemistry, spectrographic methods, calorimetry chromatography of coal extracts and coal tar fractions the principles of fluidization of solids in gas, the conveyance of solids in air, the surface chemistry of coal, the mechanism of hydrocarbon synthesis and the petrography of coal. The

absorption of moisture by coal has opened a new field of research which will be of help in understanding the nature of the reaction of combustion, slow oxidation and gasification of coal. X-ray investigations on the structure of coal and coke and on the minerals found in coal have also been undertaken.

TECHNICAL ADVICE

During 1951, tests on coal, coke and other materials were carried out for a number of firms, thereby bringing an income of Rs. 50,000 to the Institute. Technical advice on coal, oil and fuel problems was also given to Assam, Madhya Pradesh, Madras and Jammu and Kashmir.

CHAPTER V

CENTRAL GLASS AND CERAMIC RESEARCH INSTITUTE

IT is estimated that about Rs. 3.5 crore worth of glassware and about Rs. 1.3 crore worth of porcelain and chinaware are manufactured annually in this country. On the other hand, the yearly imports are valued at Rs. 2 crore and Rs. 70 lakh respectively.

Of late, the domestic demand for glassware and ceramic products has increased considerably. A large variety of these articles are needed for use at home for construction, electric transmission, illumination, electronics, optics and manufacturing processes. Soft, smooth, lustrous fabrics made of glass are also used for wall covers, curtains, lamp shades, neckties, hand bags, women's hats and garments. The forms in which glass finds application is thus of surprising variety.

Yet nothing was done for a long time to explore the possibilities of glass manufacture in this country or to establish a central scientific organization for glass technology. In 1944, however, the Council of Scientific and Industrial Research decided to set up a Central Glass and Ceramic Research Institute in Calcutta with Dr Atma Ram as the Director. The Institute was declared open on August 26, 1950, by Dr B. C. Roy, Chief Minister, Government of West Bengal.

BUILDING AND EQUIPMENT

It was planned to have a three-storeyed building for

the Institute, of which two have already been completed. It is designed in an L-form with a glass tower joining the two wings.

Among the special features of the building are the armoured-plate glass doors, the first of their kind to be installed in India. The vestibule is decorated with a mural in cut-glass in a single piece depicting the glass-blower's craft and the potter's wheel and an enamelled panel bearing the Council's insignia and the inspiring words of the Prime Minister: "Do it now. I am not interested in excuses for delays. I am interested only in things done."

The latest and up-to-date equipment has been installed at the Institute, including experimental furnaces and pilot plants. Testing facilities, hitherto unknown in India, have also been provided. Special mention may be made of the testing of refractories, glassware, enamel goods and pottery articles.

SCOPE AND FUNCTIONS

Among the subjects of study are glass, refractories, pottery and enamel. The Institute's functions include: (i) fundamental research on different branches of glass and ceramics; (ii) testing and standardization; (iii) technical assistance to industry; (iv) the dissemination of technical information; and (v) training.

Besides fundamental work, problems having direct bearing on the industries are studied. The examination of special projects and the inspection of factories are also carried out, while advice is given on planning and development.

PROGRESS OF RESEARCH

Raw Materials—Work has been done on the availability and beneficiation of sands, sandstones, etc., for glass manufacture. The results have shown that there is an

abundance of raw materials in the country. Processes have been worked out for the improvement of the quality of poorer grades and a number of units like sand-washing plants, magnetic separators, vibrating tables, etc., have been installed.

More than 800 samples of clays for the ceramic industry have so far been examined and a survey made of about 80 localities. Investigations were also carried out on the properties of talcs available in the country.

Standardization—In collaboration with the Indian Standards Institution, articles of superior quality are being manufactured at the Institute. Specifications for glass ampoules, vaccine phials and glass sands have already been drawn up. Standards are being laid down for limestone and dolomites for glass making and clays for ceramic industry. The properties of indigenous raw materials and goods and the methods of testing them have also been examined.

Glass Containers—Specifications have been worked out for glass required for the manufacture of bottles and containers, the biggest items of production in the glass industry. These are largely used by the chemical, pharmaceutical, toilet, ink and other allied industries. Soda water bottles, which were previously imported, are also being produced in the country.

Saggars—Saggars are used for placing pottery in kilns during firing and these usually last five to six such firings. Indigenous raw materials have been used to make them and they have been found to last up to 18 cycles. They will also be cheaper to manufacture, thereby enabling them to meet foreign competition.

Sand-lime Bricks—Sand-lime bricks have been made of lime sludge and found superior to those produced from ordinary lime. In order to produce bricks of different colours, the effect of adding organic and inorganic colorants to the mixture has also been studied.

Boron Free Enamels—Borax is an essential chemical for the manufacture of vitreous enamelware and is now wholly imported. The annual output of this industry is worth

about Rs. 2 crore and, besides employing several thousand people, it produces a variety of articles, including utensils and hospital supplies. Enamels have now been produced from raw materials without using borax and they are comparable in quality to borax enamels.

Salt Cake—About 40,000 tons of dense soda ash are imported annually for glass manufacture. Salt cakes found at Didwana in Rajputana have been used for soda ash as also to make amber glass bottles. The use of sulphur, hitherto imported for amber glass bottles, thus becomes unnecessary.

Waste Mica—Bricks made of vermiculite are used for insulating purposes and the raw material is imported from South Africa. Insulation bricks are now made from mica and they have been found to be as good in quality as the vermiculite bricks.

Glass Bangles—Red colouring material required for the manufacture of signals and glass bangles is in short supply. Locally available materials are now used instead, thereby eliminating the use of the colouring material.

Chemical Porcelain—Laboratory or chemical porcelain articles, extensively in use in scientific and technical institutions, have so far been imported. The quality of articles produced in the laboratory, such as dishes, crucibles, basins, etc., is not inferior to that of the imported articles. These will reduce imports and also meet the demands of educational institutions.

Wire Wound Resistors—Enamel coated resistors are used in electrical installations and radio communications. These are entirely imported, but low and high ohmic value resistors and their enamel compositions have now been made at the Institute.

Ceramic Colours—A variety of ceramic colours are now imported; but a large number of underglaze and overglaze colours of different shades have been prepared. They have been found to match well in quality and performance with the colours imported for the pottery industry.

Signal Glasses—The samples of signal glasses for the

railways and other traffic installations, hitherto imported, have been made and have successfully stood the test under operating conditions.

Automobile Spark Plugs—At present, spark plugs worth about Rs. 15 to Rs. 20 lakh per annum are imported for use in automobiles. Experimental spark plugs made at the Institute have given satisfactory performance and about a thousand spark plugs are being produced for trial by motor works and dealers in motor parts.

Dental Porcelain—Artificial teeth are being made cheaply at the Institute and these will eventually replace imported artificial porcelain teeth.

Foam Glass—Foam glass is used as thermal insulating material in housing and refrigeration industries and as a substitute for cork. Samples produced at the Institute have been found to be as good as the imported material.

TECHNICAL ASSISTANCE

Technical assistance has been given to industry, particularly for the removal of defects, the suitability of raw materials, layout of plants, furnace designs, etc. The analysis of raw materials and the testing of glass articles for serviceability are now done on a well-organized basis. The Government departments and educational and scientific institutions have been helped with investigations and the Indian Standards Institution with the preparation of standards and specifications.

Special refractory parts are now being made in a separate section of the Institute. Scientific organizations and private firms are receiving help in tiding over difficulties created by import restrictions. About 800 parties have so far been assisted in this manner during the past three years.

FUTURE PLANS

The utilization of the country's mineral resources, the manufacture of optical glass and the production of sun glare glasses are some of the items for future investigations.

CHAPTER VI

CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE

THE real importance of food technology and processed foods came to be recognized in India for the first time during World War II. The Bengal Famine of 1943 and the threatened famine in South India in 1946 made people conscious of the value of research in food technology. The Industrial Research Planning Committee and the Food Industries Panels of the Government of India, therefore, recommended the setting up of a Central Food Technological Research Institute. Sri C. Rajagopalachari, then Minister for Home Affairs, inaugurated the Institute on October 21, 1950, at Mysore. The Director of the Institute is Dr V. Subrahmanyam.

BUILDING AND EQUIPMENT

Built on the top of a high plateau, the Cheluvamba Mansion, which houses the Institute, commands a magnificent view of Mysore city and its environs. The building stands in the midst of extensive cultivated fields and fruit trees. It contains 130 rooms and a block of 50 rooms in the rear. Between the two wings, there is the mosaic coloured Assembly Hall for meetings and conferences.

The laboratories are among the best in the world and are equipped with all the necessary facilities, including cold storage, for research. Special chambers have been designed for work on refrigeration.

The museum contains samples of processed food products manufactured in India as well as those standardized at the Institute. These include biscuits, fruit juices, cordials, syrups, breakfast foods, jams, *chutneys*, pickles, fats and oils, canned fruits and vegetables. An animal house is also attached to the Institute.

SCOPE AND FUNCTIONS

Considerable scope exists for the development of new and improved methods of storage of staple foods and perishable stuffs like fruit, vegetables, meat, fish and dairy products. Moreover, new developments are to be expected, such as the reclamation of insect infected foodstuffs, their conservation and preservation and the elimination of harmful constituents, the refrigeration and freezing of foodstuffs, the conversion of non-edible foods and the production of substitute foods. The yield from staple foods can also be improved and saving effected on costs of processing like milling, parboiling, millet-rice making, the formation of synthetic rice and other substitute foods. Food technology thus offers a vast field for investigation.

Among the subjects of research at the Institute are the following: (i) the storage and preservation of food materials; (ii) the processing of foodstuffs to improve their conservation; (iii) the treatment of coarse food materials to better their food value; (iv) the study of new and hitherto unfamiliar sources of food materials; (v) the preparation of concentrated foods, vitamins and other food accessories; (vi) the preservation of fruit, vegetables and other perishable articles and the preparation of squashes, jams, pickles and *chutneys;* and (vii) training in food technology.

RESEARCH AND DEVELOPMENT

Storage and Preservation—Work on storage and refrigeration includes the treatment of grains with mercury

vapours and the results have been found satisfactory. The infestation of soft wheat by insects showed that while weevils caused a heavy loss of weight, cocoa moths fed only on the germ portions and brought about a heavy reduction in the viability of grains. It was also observed that there was an increase in the content of sugar and the acidity of fat and a decrease in the thiamine content and solubility of protein.

Other methods developed at the Institute include the impregnation of jute bags with a weak solution of insecticides for the storage of grains, the sprinkling of tomorin along the walls of food stores in order to control damage by rats and devising methods of preservation of salt roasted cashew kernels at ordinary temperatures for periods of seven months.

Optimum conditions of temperature and humidity have been determined for the storage of potatoes, mangoes, oranges, limes, jack-fruits, brinjals, cabbages, cauliflowers, beet roots and knol knols. Thus, potatoes can be preserved for eight months, Sathgudi and Coorg oranges for three to five months, ripe mangoes and mango slices for one year and shell eggs of the white Leg Horn and Barred Plymouth Rock for nine months.

Processing Techniques—Among the techniques evolved for the processing of fruit and vegetables are those for new processed products. At the same time, methods have been standardized for the canning of field beans, green jack-fruits and curried vegetables as well as for the preparation of pectine from jack-fruit waste, papayas, wood-apples and guavas, of products like chips, toffees and glazed figs from bananas and fruit juice powders and concentrates from oranges, mangoes, papayas, pineapples, guavas and grapes.

The cashew apple has been used to make jam, candy and pickles. Twelve different products, such as pickles, *chutneys,* preserves and candy, have been prepared from tender bamboo shoots after they have been freed from harmful ingredients. Ripe jack-fruit bulbs have been canned and used to make toffees.

Vanilla essence has been prepared from Indian vanilla beans and fruit bars from amla which is twenty times richer than oranges in vitamin C. Techniques have also been worked out for the removal of the bitter aftertaste of orange juice and squashes, for the production of fungal distaste from wheat bran and for the preparation of fungal pectinase from the Penicillium notatum for cleaning fruit juice.

New Processed Foods—At present, large quantities of infant and invalid foods are obtained from foreign countries at a huge cost. Some of these products are being manufactured and the processes have been covered by patents.

To meet the shortage of milk and milk products in the country, a palatable, suitably fortified vegetable milk has been prepared from groundnuts. One pound of groundnut yields about 8 lb. of milk. Its price is about a third of that of cow's or buffalo milk and it is equally nutritious. Excellent curds and buttermilk can be made from it. More than 150 lb. of vegetable curds are thus prepared and supplied every day to the hotels and catering establishments in Mysore.

The shortage of cereals constitutes the major food problem for this country. Experiments have shown that up to 25 per cent of rice, wheat or millet can be replaced by tuber products like tapioca without any adverse effect on health. Synthetic rice, for instance, has been prepared from tapioca flour and groundnut cake flour. It tastes like rice and is cooked in about a third of the time taken by it. Both tapioca and groundnut are extensively grown and are easily available. A method for preparing glucose from tapioca starch has also been evolved.

A highly nutritious protein food in the form of grains, rods and flour has been prepared. It contains 25 per cent protein and a fully balanced complement of carbohydrates, minerals, vitamins and fats. It has been found to be especially nutritious in wasting diseases during convalescence.

Experiments concerning the poor "shell-life" of Indian biscuits have shown that a hydrogenated and blended

vegetable shortening is superior to the one now being used by manufacturers in India. The digestibility, absorption and overall nutritive value are not affected by the higher melting point of the shortening. The manufacture of such shortening has now been authorized for use by the biscuit industry.

A method has also been developed for the preparation of edible and industrial starch from the banana stem which has hitherto been wasted. Each stem yields 1½ lb. to 3 lb. of starch and makes good quality custard powder. The mash liquor yields a mineral fertilizer rich in potash and the fibre can be used as fodder.

Moreover, *suji* and flour of good quality have been made from tapioca and composite protein food with a casein base. The latter is flavoured and fortified with vitamin B and essential minerals. It is a highly concentrated food and has been found useful in wasting diseases.

Methods have been standardized for the preparation of malted milk powder from *ragi* malt extract and milk. It has an acceptable taste and a good flavour and compares favourably with well-known imported brands. Two kinds of foods for infants and invalids, with and without cocoa, have also been prepared.

A cheap and nutritive product called 'Mysore flour' has been made from tapioca and groundnut cake. In some of the gruel centres in Madras and Mysore States, 5,800 people were fed daily on this food and it proved its value in areas where there was a shortage of rice.

New Beverages—Recipes have been evolved for cold drinks made from indigenous fruit. The ginger cocktail, a non-alcoholic beverage, for instance, has become popular. An excellent beverage called the passion fruit squash has been made from passion fruit which grows wild in Coorg and the Nilgiris, while an invigorating drink is derived from the cashew apple, 5,500,000 maunds of which are wasted annually. Tonic wines have been made from Indian fruit

and mint liquor and new beer-like beverages have also been made.

A good squash called 'jack nectar' and slabs of attractive colour and flavour have been prepared from ripe jack-fruit bulbs as well as a thick syrup from jack-fruit rind. A new beverage, 'Pansupari' nectar, has been prepared from the ingredients used in *panbeeda.*

It has been found that coffee husk, which contains 0.2 to 0.6 per cent caffeine and is a non-edible waste material, can be used to make French coffee in the same way as chicory, an imported item costing Rs. 10 million. Investigations are under way to devise methods for the detection of adulterants in coffee, for the preparation of a soluble coffee and coffee tablets, for a "wetting technique" to get more cups of good quality coffee from a given amount of powder and for the development of quicker techniques of processing parchment coffee.

QUALITY CONTROL

Investigations have also been carried out on little known foods in order to utilize them for supplementing the food supply or for industrial purposes. For instance, it has been found that the seeds of *Amaranthus paniculatus* (Rajgira) are rich in protein of high biological value and are about three times as nutritious as rice. The puffed grains of this plant can be a cheap and nutritious breakfast food.

Research on *agava vera cruz,* which grows under semi-arid conditions and is commonly used for fencing, showed that the tuberous part of the stem is rich in polyfructosans. The latter has been converted by simple acid hydrolysis to fructose, a very sweet and costly sugar which is of special interest to the confectionery industry. Garlic and onion have also been found to contain polyfructosans and to have a carbohydrate make-up similar to that of *agave.*

The method of detecting adulteration of *ghee* has been standardized by the use of phenolphthelein. Qualitative chromatographic analysis of carbohydrates and amino acids

has also been carried out on a number of articles of food, including potatoes, carrots, beet roots, knol knol, red marrow, ash gourd, small gourd, cucumber, coconut, betel leaf, lime fruit and guava. The nuts of *Terminalia bellerica* have been found to be rich in fat and proteins.

EQUIPMENT AND MACHINERY

While methods are being developed for the preservation, processing and utilization of food material, equipment and machinery have also been designed and built for research projects. These include equipment for flash pasteurization of beverages; deodorizer for the removal of nutty flavour in vegetable milk; pilot plants for the extraction of alcohol from oil-seeds and the preparation of synthetic grains, vegetable milk, banana starch and malt; rasper for the manufacture of starch from tapioca; the forced circulation vacuum evaporator and a jet condenser for vacuum concentration of thin liquors, milk and juices; and a new type of thin film evaporator for the concentration of highly viscous liquids, besides special types of evaporators, stills and vacuum dryers.

TECHNICAL AID

The technical aid programme embraces advice and the supply of information to food processing industries and interested persons. Bibliographical surveys of literature on food technology, statistical studies of raw materials for food industries and their finished products and nutritional and diet surveys on special projects have also been carried out. Articles and abstracts from journals have been translated, while a quarterly bulletin on the progress of food technology in European countries is being brought out, in addition to a monthly journal. Finally, about 40 leaflets and one brochure have been published to encourage food industries on a small scale.

CHAPTER VII

NATIONAL METALLURGICAL LABORATORY

In order to ensure the growth of metallurgical industries in India, the Council of Scientific and Industrial Research decided, in 1942, to establish a National Metallurgical Laboratory. Accordingly, a National Metallurgical Laboratory Planning Committee was constituted in the following year. The foundation-stone of the Laboratory was laid on November 21, 1946, by Sri C. Rajagopalachari, then Minister for Education and Arts in the Interim National Government, and it was opened by the Prime Minister on November 26, 1950.

Speaking on the occasion, Professor Charles Crussard said: "India is one of few countries to build a National Metallurgical Laboratory . . . . This Laboratory is exactly of the right size for a self-contained unit."

Mr E. H. Bucknall is the Director of the Institute.

BUILDING AND EQUIPMENT

The Laboratory is located at Jamshedpur in a three-storeyed building. It has, in addition, a technological block and the service facilities comprise the supply of electricity, gas, water and compressed air. The first floor, a part of the ground floor and the conference room on the second floor are air-conditioned.

Among the equipment provided at the Laboratory, special mention may be made of the machine shop fitted

with the latest models for the preparation of specimens and for the repairs and fabrication of plants, machinery and apparatus. The heat treatment shop, the foundry and the mechanical testing laboratories also have the latest types of machinery. A complete batch testing laboratory has been erected for ore-dressing and mineral beneficiation. Similarly, up-to-date machinery, kilns and furnaces have been installed for the preparation of refractories. The Laboratory is thus equipped to serve as a centre of research on ores, minerals, metals, alloys and refractories.

SCOPE AND FUNCTIONS

Among the Laboratory's main functions are: (i) the application of the results of research to commercial conditions; (ii) the testing and standardization of manufactured products; (iii) the collection of data and technical information; and (iv) the provision of facilities for the solution of industrial problems. This work is carried out in the following six divisions: (i) general metallurgy; (ii) physical metallurgy; (iii) chemical metallurgy; (iv) refractories; (v) ore-dressing and mineral beneficiation; and (vi) technical metallurgy and testing.

RESEARCH ACTIVITIES

The number of investigations in progress at any time has, on an average, been about fifty. The projects at hand vary from those of immediate practical importance like the beneficiation of ores to those of high theoretical importance, such as the study of bainite formation in steels.

Beneficiation of Ores—It is estimated that for every ton of mined high-grade manganese ore nearly three to four times the weight of low-grade ore are left at the site. The deposits of manganese in the country are, however, by no means unlimited. Beneficiation experiments by thermal treatment of low-grade manganese ore (36%) have been carried out and a 50 per cent concentrate has been recovered from the slags.

Metallic ores, as found in nature, are not always suitable for direct processing unless improvement is brought about in the grade by ore-dressing processes. Ore-dressing techniques are, therefore, being developed for different ores. Low-grade chromite ores from Dodkanya (Mysore) and Kittaburu (Bihar) have already been examined, while samples from Talur, Arsekere and Dodkatur in Mysore are being studied.

Sulphur is an important industrial raw material. To make up for its shortage in the country, experiments are being made to utilize low-grade pyrites from Wynaad (Nilgiris), Karwar (Bombay) and Chitaldrug (Mysore) by concentration. Preliminary investigations have shown that the latter may yield about 150,000 tons of sulphur after suitable beneficiation.

The low-grade wolfram ore from Rajasthan has been up-graded and a marketable concentrate produced. Of topical interest in the atomic age is the method employed for the concentration of low-grade uranium ores.

Metal Extraction and Refining—Experiments have been carried out on the production of nodular cast iron, using an alloy of 75 per cent copper and 35 per cent magnesium. Nodular cast iron can be used to replace steel castings and this is important as there is a shortage of steel in the country. The mechanism of graphite formation in nodular cast iron has also been studied in order to apply the process to Indian pig iron.

The manufacture of electrolytic manganese, beryllia and titanium has been investigated. Already, manganese has been produced by this process on a laboratory scale and pilot plant experiments have been planned. The method of making beryllia by chemical, electrolytical and chlorination processes is being investigated. A pilot plant scheme has been drawn up for the chemical production of 2,400 lb. of beryllia annually.

Nearly 300 tons of ilmenite is found in the country and it is the principal ore for titanium. Investigations have been undertaken to prepare metallic titanium, the wonder

metal. An electrolytic method of extracting the metal is also being developed. The production of high purity manganese dioxide for dry battery cells will begin shortly on a pilot plant scale.

Alloys of aluminium and silicon are widely used in the engineering and automobile industries, but they are at present expensive to prepare. Experiments are afoot to discover an inexpensive process for their production.

The Mint at Bombay referred to the Institute the problem of recovering nickel from silver-refinery waste liquors. A method of separating zinc as sulphide and nickel electrolytically has been worked out.

At the instance of Messrs Tata Iron and Steel Co. Ltd., research was undertaken on the manufacture of low carbon ferro-chrome by reducing chromite with ferro-silicon and the results were satisfactory.

Substitution of Scarce Metals—The possibility of replacing plated steel and other materials by aluminized steels to conserve nickel, chromium and tin has been examined. The process of dip-coating and heating mild steel with a packing of aluminium, alumina and ammonium chloride has been studied in this connection.

The response of alloy steels to the addition of aluminium and heat-treatment is under study. The amount of aluminium to be added to produce maximum inhibition to growth in plain carbon as well as in nickel chrome steels has been ascertained. The control of grain size by such addition improves the mechanical properties of steel.

The established alloys for permanent magnets contain nickel and cobalt which are not found in the country. An attempt is, therefore, being made to develop permanent magnet alloys of iron, manganese and aluminium. The alloys of Fe-Mn-Al prepared both by the powder method and by melting, casting and annealing have been shown to retain magnetism. Incidentally, it has been found that some Fe-Mn-Al alloys show resistance to corrosion and to high temperature oxidation.

Refractories—India has one of the largest deposits of

sillimanite in the world, but they have not so far been properly utilized. It is obtained as a by-product in the process of extracting monazite and ilmenite from the sands on the beaches in Travancore. Suitable sillimanite refractory compositions and methods of processing are being evolved by preliminary investigations and tests of these products. Work on the manufacture of graphite, sillicon carbide and super-basic refractories is in progress. It is anticipated that these will compare favourably with the standard imported goods.

Petrographic studies are also being made on raw materials for refractories.

Plating Industry—Among investigations undertaken on electroplating, the substitution of cyanide by non-cyanide baths for the electroplating of brass, the technique of plating metals on non-metals like glass, wood, paper and porcelain and chromium plating on aluminium constitute some of the important achievements.

Mechanical Metallurgy and Testing—The users of metal products are naturally interested in testing specific performances of the products they buy. In this connection, considerable work has been done on the wear of railway wheels, tyres and axles, while the role of wear products in accelerating wear has been determined. Work is being continued to correlate wear resistance with the physical properties and structure of materials. Other items of investigations include the study of the impact fatigue resistance of structural steels and of the fatigue properties and notch sensitivity of structural steels and aircraft alloys.

AID TO INDUSTRY

Two types of problems have been referred to the Institute by industrial and Government organizations. One involves investigations of an industrial process or schemes of development, the other relates to the examination of operational difficulties or service failures.. As an example of the first type, mention may be made of the work done

for the aluminium industry on the disintegration of Soderberg electrodes and on the separation of cryolite from the carbon dust produced in the reduction furnaces. A solution has been found for problems of plating experienced by the *jari* plating industry in Surat owing to bad colour, burnt deposits or to non-deposition, thereby raising its output. The successful recovery of nickel and zinc from waste liquors after silver and copper have been recovered from old silver coins is an instance of research done for the Mint in Bombay.

Among the other items of interest is the one concerning the prevention of future accidents from the failure of four droppers of the overhead traction equipment on the Bombay-Calcutta mail. The failure of a gear-box assembly in the gypsum grinding plant at Sindri is being investigated. The testing of samples of bricks for refractory properties, ore-dressing tests, heat treatment and the testing of coiled springs used in railway wagons and the cause of excessive dross formation in a galvanizing plant are examples of enquiries undertaken on behalf of industry. Besides their scientific implications, the examination of service failures are valuable in supplying an important link in the development of contacts with industrial concerns in the country.

CHAPTER VIII

CENTRAL DRUG RESEARCH INSTITUTE

A SCHEME of intensive research in drugs and pharmaceuticals must, of necessity, form an integral part of any health plan for India. The vastness of the problem may well be realized from the fact that for numerous killing or disabling diseases, which have a high incidence in India, there is either no effective treatment or the available remedies call for much improvement.

Again, although valuable investigations have been conducted on indigenous drugs in the past, there has been little co-ordinated work embracing chemical, pharmacological and clinical aspects of drug research. This lack of collaborative effort is largely responsible for the present unsatisfactory position of drug research and drug industry in the country. Drug research should, therefore, be organized in a way similar to that in the United Kingdom, the U.S.A., Germany and Switzerland. This can best be achieved by establishing a central institution where close co-operation in research programmes can be maintained among different groups of scientists.

These considerations apart, though the medical science has made great progress, our people do not always enjoy the full benefit of modern discoveries. Imported drugs are expensive and out of the reach of the majority.

It is well known that a rich variety of medicinal plants exist in India and valuable drugs can be made out of them. Little has, however, been done with these natural resources.

Finally, in spite of the fact that a number of medicines

in the *unani* and *ayurvedic* systems have proved their efficacy, they have not yet been analysed scientifically.

The Pharmaceutical and Drugs Committee of the Council of Scientific and Industrial Research accordingly recommended the setting up of a Central Drug Research Institute. The Institute is now housed in the historic Chattar Manzil Palace in Lucknow which is a gift from the Government of Uttar Pradesh.

Presiding over the opening ceremony, Sri Homi P. Mody, then Governor of Uttar Pradesh, observed: "India has passed another milestone in her march to progress. One more laboratory has been brought into existence harnessing progress in science." Sri Govind Ballabh Pant, Chief Minister, Uttar Pradesh, also said : "Here in this Institute science will be doing its right job. It will be playing the role of a benefactor and a builder. I trust that the discoveries made here will benefit not only the millions in this land, but all others who stand in need of succour and relief, even in the obscure corners of our common world."

The Institute was able to secure the services of Sir Edward Mellanby, whose contribution to medical research is internationally known. The present Director of the Institute is Dr B. N. Mukerji.

BUILDING AND EQUIPMENT

The Chattar Manzil Palace is nearly 200 years old and has had to be suitably altered for the requirements of research. A number of divisions are to be found on the ground floor, besides a museum, an auditorium and a library. A number of laboratories with ancillary rooms are on the first floor.

An E-shaped, fly-proof, two-storeyed building contains the animal house where white mice, rats, guinea pigs, rabbits, cats and monkeys live in equable temperature. Several of its rooms are air-conditioned. They have a verandah where the animals can take exercise.

Among the latest modern equipment provided at the

Institute are a long paper kymograph, isolated organ baths, heart perfusion apparatus, stroke respiration pump, binocular microscopes, ultra-violet accessories, x-ray unit and electrocardigraph.

SCOPE AND FUNCTIONS

Drug and pharmaceutical research provides very wide scope in India. The research activities at the Institute will thus embrace an extensive field extending from a systematic study of the crude drugs that have been in use in the indigenous systems for centuries to the highly developed field of synthetics and antibiotics.

Nearly 35 per cent of the drugs listed in the British Pharmacopoeia are native to India and probably substitutes for a large number of others can be found. Much of the country's indigenous drug resources are still unexplored and the Institute will have to organize systematic work in this field. It is also proposed to examine the techniques of investigation developed in the West for synthetic drugs and to adopt them for the study of such Indian drugs as might be useful in the treatment of the most common diseases in the country.

Since most of the activities require team work, the co-operation of specialists in widely diversified fields will have to be enlisted. Thus, the different stages in the production of a drug will be studied by experts in their respective fields. The chemist will prepare products which will be submitted to biological tests by biochemists, pharmacologists, bacteriologists and pathologists. Finally, selected products will be tried out on animals first and then on human beings. Substances may thus be found which have either entirely new reactions on the human body or are more effective than remedies already available.

Among the essential functions of the Institute will thus be : (i) the promotion of drug research; (ii) the testing and standardization of drugs; (iii) the provision of facilities for the study of drugs; (iv) the provision of clinical trials; (v)

the dissemination of knowledge about drugs; and (vi) the training of personnel in drug research.

The ultimate object of the Institute is to stimulate progress in the control and treatment of disease through the study of diagnostic, preventive and therapeutic agents. Efforts will also be directed towards the lowering of the cost of medicinal products.

ACHIEVEMENTS

The import of antibiotics, anti-malarials and sulpha drugs involves a heavy drain on the country's resources. This can be stopped only if standard drugs can be manufactured within the country. Furthermore, local medicinal raw materials are still exported rather than utilized for industries at home. Attempts have, therefore, been made to manufacture medicinal products from indigenous herbs and plants. An effective substitute for d-tubocurarine, for instance, has already been found from *Cissampheolos pareira Linn* (Zakhmi-hayat).

To encourage the use of standard indigenous drugs by physicians and pharmacists, the Indian Pharmaceutical Codex has been compiled on the model of the British Pharmaceutical Codex. Considerable progress has also been made in the compilation of the *Handbook of Indigenous Drugs of India* which will be a valuable reference manual for chemists, pharmacologists and clinicians. At the same time, a good herbarium, consisting of 700 sheets of medicinal plants, has been opened.

A series of onium, piperiolinium and quinolinum compounds have been synthesized as potential neuromuscular blocking agents. Preliminary pharmacological experiments have shown activity in a number of these compounds.

Progress has been made with important biological preparations like lecithins, nucleic acids from plants, peptones from oil-seed cakes and enzymes from bacteria. A high percentage of lecithins has been obtained from *urd* and *mung dals.*

A large number of molds and actinomyces have also been isolated. A bacterial strain isolated from a sample of soil from Lucknow has yielded an antibiotic which seems particularly active against dysentry bacillus.

Histopathological and biochemical work has been done on leucoderma. The nature of anaemia produced by lead acetate in rats is being studied to measure the potency of anti-anaemic drugs prepared at the Institute and to discover a still better treatment than the one already in existence. New approaches to the treatment of diabetes and high blood pressure are also being made and preliminary results appear promising.

FUTURE PLANS

The Institute is entering its third year, but much leeway has still to be made up in the organization of research programmes. It is proposed immediately to take up studies on the chemistry as well as pharmacological and therapeutic uses of the rich collections of Indian materia-medica with a view to evolving useful drugs. Work already under way appears to indicate that a good drug for high blood pressure may be obtained from an indigenous plant used for centuries in this country. Similarly, valuable work is possible in the field of anti-tubercular agents and anti-dysentrical remedies.

A major item of research during 1954 will be the study of brain waves, besides such problems as sleeplessness, insanity, mental aberration, etc. Investigations will also be undertaken to find out an effective remedy for a condition known as 'Sehizoph.'

The mechanism of pigment formation and the way pigment can be deposited on leucoderma patches are being studied. This will open up new lines of treatment which have eluded the scientists so far. Furthermore, studies are being planned to evolve suitable oral contraceptives as distinguished from those now employed locally. These will have immediate application to the problems of population control and family planning.

OTHER ACTIVITIES

Besides developing new ideas on research, the Institute will become a centre for the training of scientific personnel. Already, such facilities are being provided for trainees from the States, universities and research institutions. As a clearing house for information on drugs, it already ranks as a primary centre for reference and the dissemination of scientific knowledge.

Finally, attempts are being made to popularize drug research in the country by organizing symposia, discussions, extension lectures and radio talks. In this way, active public interest is being created in a field of knowledge hitherto very little understood in this country.

CHAPTER IX

CENTRAL ROAD RESEARCH INSTITUTE

THE importance of roads for the growth of trade and commerce has been recognized in India since early Vedic times. There is, for instance, evidence, dating back to the Mohenjodaro period (C. 3,000 B. C.), of the skill of Indians as road engineers.

At present, however, India lags behind many countries in road development. Thus, with an area of over 11 lakh square miles, she has only 255,460 miles of roads. This works out to about 0.22 miles of roads per square mile, and of this barely a third is suitable for motor traffic. Compared with this, the United Kingdom has 184,000 miles of roads for only 94,000 square miles and the U.S.A. 30 lakh miles of roads for an area of 30 lakh square miles. India has not even three-quarters of a mile of road per thousand of population as against 3.6 miles in the U. K. and about 21 miles in the U.S.A.

Moreover, the methods of road construction and maintenance are stereotyped and the condition of the roads remains poor. Some experimental field work has, of course, been done in different parts of the country, but this is largely unco-ordinated. Adequate facilities for road research were, however, practically non-existent until recently.

The Industrial Research Planning Committee of the Council of Scientific and Industrial Research, therefore, decided, in 1944, to create a Central Road Research Institute and a Road Research Planning and Advisory Committee was constituted to draw up plans for its establishment. A suit-

able site was secured on the Delhi-Mathura road. This was a gift from His Grace the Archbishop of Delhi-Simla and the choice was fortunate in that this road carries heavy mixed traffic which can be diverted over the test tracks for experimental purposes.

The foundation-stone of the Institute was laid on September 6, 1950, and it was opened by the Prime Minister on July 16, 1952. Dr E. Zipkes is the Director of the Institute.

BUILDING

The plans provide for a three-storeyed building for the Institute, but so far only the ground floor has been completed. The halls for research divisions have been built with a span of 60 feet and without central pillars, the roofs being composed of five thin continuous shells of reinforced concrete. Out of the total capital cost estimated at Rs. 29.64 lakh, nearly Rs 19 lakh have so far been spent on the construction of the building.

SCOPE AND FUNCTIONS

The main function of the Institute is to find a solution for the varied problems of road construction, maintenance and improvement. Special attention is, however, given to the following: (i) fundamental research on materials for road construction; (ii) correlation of laboratory tests with those under actual conditions; (iii) tests on soil and studies of soil mechanics for building low-cost roads; (iv) the standardization of specifications for roads; (v) the design of instruments for tests on roads; (vi) studies of the different types of roads under different traffic conditions; (vii) the dissemination of the results of research; and (viii) the training of technical personnel.

Emphasis is laid on low-cost, all weather rural roads and their construction from locally available material. Test tracks will be laid in different parts of the country and the

results checked under service conditions in different localities.

The work of the Institute is done in the following divisions: (i) soil; (ii) rigid pavement; (iii) flexible pavement; (iv) road; (v) traffic engineering; and (vi) economic and statistical research.

Close co-operation has been established between the Institute and the Roads Organization of the Union Ministry of Transport and other research and experimental stations on the one hand and similar institutions in foreign countries on the other.

PROGRESS OF WORK

Although the Central Road Research Institute was opened in July 1952, technical work began much earlier. The study on the compaction of soil for comparison with the one prepared in England was undertaken, besides another on the identification of Indian black cotton soil. Investigations have also been carried out on specifications for surface dressings and on materials not generally used for road construction.

Since June 1953, a test track of about 5 furlongs on the Bombay-Delhi national highway has been attached to the Institute. The tests, at present, consist of nine different surface specifications with tar and bitumen. Parallel to the test track, a permanent diversion was constructed over which traffic was diverted while work was in progress.

Technical assistance for engineers and engineering institutions mostly concerns difficulties which need immediate attention, even though the solution of the problem may take long involving fundamental research. The problem may, for example, be to find new materials for road construction when a particular construction material is no longer available.

Technical assistance is also given in cases of urgent need with no nearby institution to help quickly. Thus a team of engineers was sent to Chandigarh to do load bearing

tests for multi-floored buildings. Similar work was done for several new buildings in Delhi also.

The notes published by the Institute concern (i) the examination of black-top surface dressings laid for field tests in 1945 on the Bombay-Delhi road; (ii) observation on air-field runway surface; (iii) the compaction of alluvial soils in India; (iv) investigation on some laterites; and (v) the compaction of tensile briquettes in cement testing.

FUTURE PLANS

As the object of research is to add to the basic knowledge of the engineer, almost all aspects of highway engineering and traffic surveys are dealt with at the Institute, including the compilation of road statistics. It is necessary not only to construct more roads but also to build them according to requirements. The effects of various kinds of traffic and means of transport have to be studied on different kinds of roads. Suitable notice boards, light signals, road round-abouts and traffic crossings are some of the subjects which have to be dealt with by the road engineer. The better the road engineer, the easier the task of the traffic police.

The work of the Institute may thus become very important in the future, not only because there is need for better roads in the country, but because roads play an important part in the overall life of the nation. Without proper roads, agriculture, industry and commerce cannot develop. The building of more roads is the key to the country's economic and industrial progress.

CHAPTER X

CENTRAL ELECTRO-CHEMICAL RESEARCH INSTITUTE

ELECTRO-CHEMICAL, electro-thermic, electro-metallurgical and other process industries cover a wide field and include basic materials like aluminium, magnesium, zinc, lead, caustic soda and chlorine, calcium carbide, fertilizers, abrasives, special steels, carbon and graphite products and dye-intermediates. These industries have made great progress in Europe, including the U.S.S.R., the U.S.A. and Canada, but electro-chemical methods are only just beginning to come into use in this country. Even the production of elementary substances, such as chlorine, caustic soda and aluminium, was only started during World War II.

Indeed, there is immense scope for electro-metallurgy in the country. Besides steel and steel alloys, such as ferro-silicon, ferro-manganese and ferro-chrome, it is also possible to provide metals like chromium, lithium, magnesium, beryllium, manganese, cerium, thorium and zirconium. New industries based on electro-chemical technology can now be established and the existing ones expanded and improved.

At present, out of nearly 6,000 million kw. of electrical energy produced per hour, only 400 million kw. per hour, i.e., 7 per cent, is consumed in electro-chemical metallurgical industries. With the completion of irrigation and hydro-electric power projects, large blocks of electric power will become available and these could be utilized profitably by the electro-chemical industries.

The Council of Scientific and Industrial Research recognized the need for research and development in electro-chemistry. As far back as 1940, the Electro-chemical Research Committee recommended the establishment of a national laboratory for electro-chemical research. The Industrial Research Planning Committee of the Council supported the proposal.

Dr R. Alagappa Chettiar offered Rs. 15 lakh and 300 acres of land for the Institute at Karaikudi. The foundation-stone was laid by the Prime Minister on July 25, 1948, and Dr S. Radhakrishnan, Vice-President of India, opened it on January 14, 1953. "This building," he said, "has something like a *gopuram* symbolizing to all who work here for the upward aspiration of the human soul for devotion to truth. I express my fervent hope that the spirit of the great scientists may inspire the workers in the research institute."

Dr B. B. Dey is the Director of the Institute.

BUILDING

The Institute is flanked on the south and the north by the Colleges of Arts and Science and Engineering and Technology. The gentle loop of the Madras-Dhanuskhodi railway line marks the eastern boundary and to the west lies the town of Karaikudi.

The building is square and made of granite. The high tower rising to 57 feet over the main entrance is designed in the style of South Indian temple architecture suggesting a temple of learning. A special feature of the entrance hall is the plastering of the wall and the roof in traditional pattern, using what is known as Chettinad plaster, which gives a smooth, highly polished surface.

The laboratories have the necessary services, namely, gas, water and electricity as well as equipment for the supply of compressed air, vacuum and steam. Samples of raw materials and products made at the Institute are exhibited at the museum.

SCOPE AND FUNCTIONS

The scope for the improvement of the country's electro-chemical industries and the reduction in their cost of production is considerable. A large amount of exploratory, applied and fundamental research is, therefore, necessary.

Electro-chemistry being mainly a border-line subject, subjects like fuel technology, glass and ceramic, metallurgy, physical and organic chemistry and electrical and chemical engineering, for instance, are closely linked with it. This special aspect of electro-chemical research has consequently been kept in view in drawing up plans for the Institute.

The main functions of the Institute thus relate to (i) basic or fundamental research; (ii) applied research with a view to increasing the capacity and efficiency of the existing industries; (iii) investigations and pilot plant trials; (iv) the testing and standardization of raw materials and finished products; (v) the dissemination of technical information; and (vi) the training of technologists. This work has been distributed among the following divisions: (i) electro-metallurgy and furnace products; (ii) electrolytic cells; (iii) electro-deposition and allied processes; (iv) electro-chemistry of gases; and (v) research utilization and information.

ACHIEVEMENTS

Electrolytic Manganese—As the richer grade of manganese ores is mostly exported, investigations have been made to exploit low-grade manganese ores for the production of pure manganese and sulphate bath has been used with satisfactory results. Further work is in progress with the alternative chloride bath.

Meanwhile, a pilot plant has been set up and 2½ lb. to 3 lb. of pure manganese has been produced per day from the raw ore. Another unit with a daily output of 10 lb. of manganese is now in the process of erection.

Pure Potassium Chlorate—Pure potassium chlorate is required for the manufacture of munitions. A sample of

potassium chlorate was made at the Institute and was found to be 99.9 per cent pure. Common sea salt was used as the starting material.

Cuprous Oxide—Cuprous oxide is used as anti-fungus and anti-pest chemical and for painting the bottoms of sea-going vessels as protection against corrosion. The process of its production, however, remains cumbersome and the cost is heavy. Attempts are now being made to produce a standard material and to reduce costs. The results have been satisfactory and the cuprous oxide thus produced has been found to be as good as the imported material.

Calcium Gluconate—This is a well-known tonic for calcium deficiency. A few pounds have been prepared on a laboratory scale with glucose as raw material. Further work is under way whereby cheaper chemicals will be substituted for the more costly ones.

Aluminium—A large quantity of shavings and cuttings is left over in the manufacture of aluminium utensils. The scrap cannot, however, be used as cracks appear during manufacture. It has been possible to make ingots of aluminium and they have been found satisfactory.

P-Aminophenol—This material is an important dye intermediary for the dye and photographic chemical industry. A model cell capable of handling one to two pound of nitrobenzene as raw material is being set up.

Other items of research include the setting up of a smothered arch furnace for the manufacture of calcium carbide; electro-polishing of hard chromium-plating of bearing surfaces; the determination of optimum conditions for refining aluminium in the molten stage; the anodizing and dyeing of aluminium in attractive colours, the reclamation of pure metals, copper, lead, tin, zinc, etc., from scrap, such as discarded and damaged storage batteries, worn out cables and utensils, tin-cans, etc., and the preparation of high test hydrogen peroxide, heavy water, caustic soda, sulphuric acid, water-activated reserve type of primary and wet cells, activated manganese dioxide, carbon and graphite electrodes; etc.

CHAPTER XI

CENTRAL LEATHER RESEARCH INSTITUTE

INDIA is the largest single producer of hides and skins in the world. The annual production is estimated at 14.2 million pieces of cow hide, 5 million pieces of buffalo hide, 21.3 million pieces of goat skin and 15.6 million pieces of sheep skin, and their value amounts to about Rs. 40 crore. If all the hides and skins were to be tanned and finished in this country, an eventual annual production of about Rs. 80 crore worth of leather may be expected.

The Indian leather industry also ranks fourth in importance as an earner of foreign exchange. The total value of leather and leather goods exported is estimated at Rs. 30 to Rs. 35 crore annually.

In comparison with the leather industries of the West, India, however, lags behind both in the volume of production and in the quality and variety of finished leather. The bulk of her production is still carried on as a cottage industry and the methods employed are empirical. What is required is to adopt improved processes and techniques.

It is to meet this need that the Central Leather Research Institute, the tenth in the chain of national laboratories, was set up in Madras. The opening ceremony was performed on January 15, 1953, by Sri T. T. Krishnamachari, Union Minister for Commerce and Industry. Sri B. M. Das is the Director of the Institute.

BUILDING AND EQUIPMENT

The building is single-storeyed in the rear and double-

storeyed in the front and covers a floor area of 37,050 sq. feet. It contains tannery and administrative blocks and seven research laboratories as well as a museum, library and an auditorium.

The tannery has been equipped with up-to-date tanning machinery and appliances for research in tanning. Provision has also been made for investigations on leather manufacture on small and pilot plant scales.

The laboratories have also been fitted with equipment for advanced research on the science of leather, including the study of chemistry, biochemistry, bacteriology, microscopy and physical properties of leather. Its tannery is one of the best and most modern tanneries in the world.

SCOPE AND FUNCTIONS

Work here is devoted to the improvement and modernization of the leather industry in this country. This is sought to be achieved through (i) fundamental and applied research and (ii) the training of technologists.

PROGRESS AND ACHIEVEMENTS

Much of the technique of the Indian leather industry is old; hence the effort to modernize it through the application of scientific knowledge is required. Further, the glazed kid industry is being developed in order to stop large-scale export of valuable goat skins. Three processes have, meanwhile, been worked out for the rapid tannage of sole leather and this means a reduction of time from 3–4 months to 3–6 weeks.

A great variety of leather auxiliaries, such as commercial fat liquors, enzyme bates, leather finishes, etc., is imported. Research has been undertaken to develop their manufacture in the country.

The unsatisfactory condition of the Indian tanning industry is shown by the fact that it has to depend on imported wattle bark and mimosa extract. Experiments are

being conducted to find substitutes from indigenous vegetable tan-stuffs. To supplement the fast diminishing natural vegetable tanning materials, processes are being worked out to manufacture synthetic tanning materials from natural phenolic bodies and coal-tar distillation products. So far, 27 such materials have been produced.

Investigations are in hand for the preparation of synthetic tanning oils from petroleum products in order to meet the growing scarcity of vegetable and animal tanning oils. Some non-edible vegetable oils have also been sulphated and processes for commercial fat liquors have been evolved from them for the tanning industry.

Divi-divi is an indigenous vegetable tan-stuff and is rich in tannin. In spite of its plentiful supply, it is not widely used, as it ferments readily and gives a dark colour to the leather. A process has now been worked out by which fermentation is kept in check for a long period, while the colour of the tanned leather is also improved.

An important problem for investigation at the Institute is the quality of leather from 'fallen' animals. It is well known that leather from animals dying a natural death is inferior in quality to that obtained from slaughtered animals. The basic causes of deterioration are being investigated and methods evolved to minimize adverse effects. The need for such investigation is evident from the fact that India has a total cattle population of 25.5 crores, i.e., a quarter of the world's bovine population.

Finally, a number of processes have been evolved for (i) the preparation of basic salts from aluminium and from the combination of iron, aluminium and chromium for use as tanning agents; (ii) the production of leathers like glazed kid, suede, roller skins and picking bands and for upholstery and football covers; (iii) the carrying out of the three pre-tanning processes of depilation, deliming and bating in one single treatment by use of enzymes in the milk of *Akand* (*callotropis gigantia*) leaves; and (iv) the improvement of the colour and the prevention of wastage of valuable tannin by using myrobalan extract for

myrobalan nuts in East Indian tanning process. Standard specifications have also been prepared for East Indian tanned kids, goat and sheep skins.

CHAPTER XII

CENTRAL BUILDING RESEARCH INSTITUTE

BUILDING RESEARCH has assumed considerable importance in modern years. It is no longer possible to look upon buildings as just some kind of structure built from any available material on a piece of land to serve an odd purpose. The shift of population owing to changing economic and political conditions, the limited availability of land, the shortage of conventional building materials and similar other factors have emphasized the need for research in building techniques and materials so as to reduce costs and improve quality. Specialized institutes for building research have thus been established in all major countries.

In December 1943, the Council of Scientific and Industrial Research, therefore, set up a Buildings Research Committee. As an immediate step, a Building Research Unit was set up at Roorkee to work in co-operation with the Thompson College of Engineering, now the Technical University of Roorkee. The unit consisted of two sections, one dealing with research on short-term problems and the other with the planning and establishment of the Institute.

In 1950, the unit was transformed into the Central Building Research Institute. The foundation-stone was laid in February 1951 and it was opened on April 12, 1953, by Maulana Abul Kalam Azad, Union Minister for Natural Resources and Scientific Research and Education. The Institute marks the completion of eleven national laboratories.

The Prime Minister observed at the opening ceremony: "The Central Building Research Institute is not a new school or college but it is a basic institution. From here waves of knowledge will emanate to improve India and better the living conditions of our people."

Dr K. B. Billig is the present Director of the Institute.

BUILDING AND EQUIPMENT

The Institute stands on a 10-acre plot of land and 57 additional acres have been acquired for further expansion.

The main building has four blocks, the chemical and physical laboratories and the administrative offices being housed in the main block. The technological block consists of laboratory rooms and five sheds containing the soil mechanics laboratory and the workshop. Highly specialized books and journals on building materials and construction can be found in the library. The museum displays exhibits of building materials, small tools and samples of fittings and equipment.

A part of the ground is reserved for the exhibition of experimental structures. A number of experimental houses, such as low-cost houses of the corrugated concrete shell type and a precast house of prestressed concrete units, have been erected in this area.

Among the major items of equipment already installed are those for the testing of structures, building materials, concrete and soil, besides workshop equipment.

There are also a number of special outfits like those used for differential thermal analysis, a catharometer for ventilation studies, a petrological microscope and universal testing machines for the testing of materials.

SCOPE AND FUNCTIONS

Although the problems for investigation at the Institute are, by and large, the same as in other countries, some are of special interest to India. Particular attention,

however, will have to be paid to those aspects of materials, techniques and performance in which buildings in this country differ from those in temperate climates; the development of new building materials and novel processes of production, such as better use of soil by stabilization, the use of boiler ash as puzzolana to save cement, lime sludge from sugar factories as a stabilizer, filter press mud for the production of mineral wool and the use of bamboo as building material; and the construction of cheap, durable and sanitary houses for low-income groups, villagers and industrial workers.

Among the other aspects which require investigation are problems of design, functional requirements of buildings, basic studies of structures, the standardization of building components and the evolution of new materials or substitutes. Attention has also to be devoted to the nature, properties and treatment of clays, minerals and soils. Materials and practices evolved in foreign countries, too, require to be studied before they are adapted to suit Indian conditions.

The Institute will, therefore, deal with the four principal groups of problems, viz., (i) building materials; (ii) methods of construction; (iii) performance of buildings; and (iv) survey and information.

RESEARCH WORK

BUILDING MATERIALS

Soil Stabilization—The method of stabilizing soil with cement is well known. There is also the possibility of utilizing some of the industrial waste products for this purpose. Work done at the Institute has shown that lime sludge, a waste product from sugar factories and tanneries, mixed with sodium silicate, can be used for the stabilization of soil. This process may be applied for the base-course of roads for light traffic or for making blocks for buildings.

It has been estimated that the process would mean an additional cost of about 10 to 15 per cent over the cost of

ordinary sun-dried bricks. Owing to the high cost of transport, however, this material will find only regional use, say, within 8 to 10 miles of the factory where the waste product is available. Various substances like metallic rosinates, oleates, stearates, lime, alginates, glues and rosins, too, have been tried as water proofer or integral stabilizers.

Bricks—Research on bricks and brick clays was also undertaken. Shrinkage, for instance, can be controlled to a considerable extent by suitably modifying the mechanical composition of raw material like sand, silt and clay. It is also possible to get bricks of such high crushing strength as 7,000 lb. per square inch as against ordinary bricks with a strength ranging from 500 to 2,000 lb. per square inch. This opens up the possibility of manufacturing special types of strong bricks suitable for heavy structures at little extra cost.

Preliminary trials have shown that the crushing strength of the bricks made of black cotton soil from the Bombay-Deccan area does not change much over a wide range of firing temperature. It appears that the firing of such bricks can be made at lower temperature with fuel of less calorific value or with a lesser quantity of fuel.

Fluxes present in brick earths were also studied. This may help in finding methods by which the warping of bricks made out of black cotton soil may be checked during firing.

After laboratory experiments, Sindri ash was used in small proportions as admixture to the raw material for bricks. These have been fired in local kilns under ordinary factory conditions. Experiments were also planned to find methods of improving quality.

Weathering of Stones—Experiments are being carried out on the weathering quality and the physico-chemical properties of building stones.

Puzzolanas—Preliminary trials with boiler ash from Sindri have shown that it is possible to utilize this waste product to make puzzolanic cement. By this process cement may be saved by substituting ash up to 25 per cent.

Vermiculite—Exfoliation studies in Indian vermiculite from Mysore were undertaken. The effect of temperature, time and size and the method of measurement of exfoliation were determined. Cold exfoliation with oxidizing agents like hydrogen peroxide, ammonium persulphate, etc., was also tried and further investigations are in progress.

LOW-COST HOUSING

Prototypes—A mud hut, similar to those found in villages, has been constructed at a cost of Rs. 600 and the walls given a special plaster. Within a few days, however, white ants appeared in it.

More recently, a hut was constructed at a cost of about Rs. 900 with rammed earth walls and clay tile roofing. This, too, proved unsuccessful and cracked badly.

Another model was erected to show the use of clay roofing tiles laid over sawn timber and a bamboo framwork. A cement floor of stabilized soil was also provided. After 2 to 3 years of weathering, the roof gave way.

A number of panels constructed of cement-stabilized soil blocks and ordinary sun-dried bricks with different plasters and renderings have been built and are being subjected to weathering for the past two seasons. The stabilized blocks are, on the whole, behaving well. *Surkhi* lime plaster on panels with sun-dried bricks has been found satisfactory, in addition to cement wash.

Thermal Behaviour of Buildings—Preliminary work has been carried out on the thermal behaviour of some of the residential quarters for the staff. The results show the importance of proper orientation of buildings for the achievement of maximum thermal comfort.

Solar charts for architects and designers have been prepared for some typical regions, namely, Bombay, Hyderabad, Lucknow, Madras, Delhi and Calcutta.

PRACTICAL PROJECTS

CBRI Shell Houses—A few prototype structures have

been set up at the Institute to illustrate the application of corrugated concrete shells. The method of construction is shown stage by stage in one of these, while in another the finished house is shown with partitions, doors, windows, lining and painting. The house is 20 feet wide and 23 feet 6 inches long with a floor area of 470 square feet. The total quantity of material required to construct such a house is 2.8 tons of cement, 13 cubic yards of aggregate and 140 square yards of jute hessian. The cost for the structural portion, when produced in bulk, worked out at Rs. 1|12|- per square foot of covered floor area.

This type of shell house is suited for equable climate such as in areas near Bombay and Calcutta. For hot arid tracts like Delhi and certain parts of Uttar Pradesh, a double shell roof is necessary, but the cost of construction increases from Rs. 1|12|- to Rs. 2|8|- per square foot of covered floor area.

Light Duty Floors—A non-conventional technique has been used to build a light duty floor in the above shell house. It consists of an inch thick layer of concrete placed on stretched jute hessian over concrete plunger piles. The loose earth which supports the jute hessian during the construction of the floor settles after a few weeks and an insulating air gap is formed. Thus the floor is cool in summer and warm in winter. Live and dead loads of the floor are entirely carried by the piles. The cost of such floors is estimated at Rs. 34 per 100 square feet.

Twin-twisted Steel Bars—In Europe and America a process is used for improving the strength and other qualities of reinforced steel by the twin-twisting of two steel bars into one stranded unit. This process of cold deformation raises the yield strength of the ordinary mild steel by 50 per cent. The building regulations of almost all Western countries, therefore, allow a 50 per cent increase in the working stresses for this steel. In other words, two tons of the twin-twisted steel do the work of three tons of ordinary mild steel. A saving of a third of reinforced steel can thus be obtained.

A capital expenditure of approximately Rs. 50,000 is normally required for the plant producing twin-twisted bars. By introducing a radical simplification in this process, the Institute has set up a small pilot plant of simple equipment made in a local workshop at a cost of less than Rs. 2,000. This will make it possible to produce twin-twisted bars at small capital cost and the process could be used on all major construction jobs with a considerable saving of steel.

PUBLICATIONS

As many as 27 publications, including 4 bulletins, have so far been issued by the Institute. Special mention may be made of (1) *Moisture Movement and Weathering Properties of Building Materials,* (2) *Need for Soil Stabilization,* (3) *Possibilities of Using Earth as a Building Material in India,* (4) *Low-cost Houses,* (5) *Village Housing in India* (6) *Environmental Factors and Human Comfort,* (7) *Studies on Indian Bricks and* (8) *Comforts and Buildings.* Among the bulletins, the following may be mentioned: (1) *Research and Building Construction in India,* (2) *Present Position of Brick Manufacture in India,* (3) *Corrugated Concrete Shell Structures and* (4) *Survey of Brick Production in India.*

CHAPTER XIII

CENTRAL ELECTRONICS ENGINEERING RESEARCH INSTITUTE

Now that eleven national laboratories have been completed, the opening of more research institutes and laboratories is contemplated. Already, three more laboratories have been planned and the Central Electronics Engineering Research Institute is one of them.

Today, electronic devices play an increasingly important part in science and industry. Their application in the field of communications, particularly broadcasting, is familiar to all. During World War II, spectacular developments were made in the use of electronic devices for military purposes, such as radio location of aircraft and submarine. Electronic machines are also employed to solve complicated equations and save much laborious calculation. Problems, which mathematicians would require years to solve, are thus solved by these machines within a few hours. In industry, too, electronic equipment has been used to melt metals, heat plastics and control chemical processes. Indeed, there is hardly any branch of modern technology or industry that has not been aided by research in electronics.

RECENT DEVELOPMENTS

To the development of this comparatively new science and its widening application, India has made but little contribution. Research in radio and electronics has been

confined only to a few centres like the Calcutta University Institute of Electronics, the National Physical Laboratory of India, New Delhi, the Tata Institute of Fundamental Research, Bombay and the Indian Institute of Science, Bangalore. These centres are, however, not able to meet all our needs.

CENTRAL INSTITUTE PROJECT

In October 1950, Sri G. D. Birla offered to donate Rs. 21 lakh non-recurring and Rs. 50,000 recurring grants on behalf of the Birla Education Trust for the establishment of an Institute at Pilani. A local committee has been constituted to draw up plans and estimates for the Institute.

Meanwhile, the Prime Minister laid the foundation-stone of the Institute on September 21, 1953. On this occasion, he said: "The future of India is connected with what we are building here. We will not get immediate results from such institutes, but they will help in laying strong foundations for new India. Such institutes are vital for the life of the country and will give good results in the future." In this connection, Maulana Abul Kalam Azad observed: "The proposed institute will fill the lacuna in one of the basic fields of modern scientific research in India."

Dr N. B. Bhatt has been appointed the Planning Officer of the Institute.

BUILDING

Land measuring 701 *bighas* and 3 *biswas* at a cost of Rs. 143,000 has been acquired for the Institute.

The total floor area required for housing the various divisions of the Institute is 140,000 sq. ft. The main building will be a multi-storeyed structure containing the testing laboratory, library and administrative offices. The technological block will have the workshop, pilot plants, heavy machinery, furnaces and presses. In the first stage of

development, the built-up floor space will be 20,000 sq. ft. in the main building and 45,000 sq. ft. in the technological block. The capital expenditure in the second stage of development is estimated at Rs. 19.0 lakh.

SCOPE AND FUNCTIONS

The object of the Institute will be to undertake research and development on all aspects of electronic engineering. Special attention will be devoted to the utilization of indigenous raw materials for the manufacture of components, the development and use of electronic circuits for industry, the building of standard electronic instruments for conducting tests, investigations on radar and other types of equipment and the application of electronics to metallurgy. The Institute will also undertake projects sponsored by industry.

It is proposed to open the following divisions immediately : (i) electronic circuits; (ii) electronic components; (iii) electronic instruments; (iv) acoustics-audio equipment; (v) ultra-high frequency and very-high frequency equipment; (vi) library and information; and (vii) workshop.

CHAPTER XIV

CONCLUSION

Six years are, perhaps, an insignificant period in a nation's life. Yet the years since independence have been years of prodigious activity in the sphere of scientific and industrial research in this country. For not only has the foundation for organizing science on a national scale been truly laid, but favourable conditions for the cultivation of science have been created.

Indeed, nothing can contribute more towards the rapid building up of a prosperous India than wide research in science and its practical application. The problem is being solved by the opening of a chain of national laboratories, which are not only magnificent and impressive in appearance but have also become homes of creative effort and work. Truly, they not only form a landmark in the history of scientific and industrial development, but represent the first systematic and planned effort to apply science and technology to the growth and development of India's national industries.

Having passed the formative stage, the national laboratories have already begun work by undertaking the assessment of resources, conducting tests and evolving standards, developing useful processes and giving advice to the Government and industry. Laboratory investigations have been completed on a number of projects. Among these are the manufacture of dicalcium phosphate and nicotine from tobacco waste, citric acid, calcium gluconate, vitamin C, electrolytic production of beryllium oxides, etc.

Meanwhile, research on coal washing and coal blending has led to several useful applications. The possibilities of using Didwana salt cake in the manufacture of certain types of glass have been established, the composition for the manufacture of railway signal glasses has been worked out and investigations completed for the improvement of the quality of salt. A study of the structure of bamboo has revealed the potentiality of bamboo as a raw material for the manufacture of newsprint.

A number of by-products and waste products from certain industries have been effectively utilized for the development of new processes. The utilization of lime sludge from Sindri, the manufacture of dicalcium phosphate, *kotka* phosphate and nitrophosphate fertilizers and the production of sulphur by microbiological reduction are some examples. Standards have also been laid down for various raw materials and finished products in collaboration with the Indian Standards Institution.

Meanwhile, the services of the national laboratories are being utilized more and more by industries for the solution of their problems. The translation of the results of research into large-scale production or application has also received special attention. Recently, the Government have set up the National Research Development Corporation of India. Its chief objective is to speed up the progress of research in the country and to ensure better utilization of its results.

Finally, a "scientific temper" has been created in the body politic. While, in general, nations turn to science under the impact of war, India has deliberately set out to recognize in science the role of a benefactor in the peaceful construction of national wealth and well-being. The discoveries that will be made in these laboratories will benefit not only millions in this country, but others even in the obscure corners of the world we inhabit in common.